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Acting Director
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CNRO-2004-00020

April 15, 2004

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

SUBJECT: Waterford 3 Relaxation Request #4 to NRC Order EA-03-009 for the Control Element Drive Mechanism Nozzles

Waterford Steam Electric Station, Unit 3
Docket No. 50-382
License No. NPF-38

REFERENCES:

1. Entergy Operations, Inc. letter CNRO-2003-00038 to the NRC, dated September 15, 2003

2. Entergy Operations, Inc. letter CNRO-2003-00049 to the NRC, dated September 26, 2003

3. Entergy Operations, Inc. letter CNRO-2003-00050 to the NRC, dated October 2, 2003

4. Entergy Operations, Inc. letter CNRO-2003-00052 to the NRC, dated October 8, 2003

5. Entergy Operations, Inc. letter CNRO-2003-00057 to the NRC, dated October 24, 2003

6. NRC letter to Entergy Operations, Inc. (TAC No. MB9542), dated November 12, 2003

Dear Sir or Madam:

In Reference 1, Entergy Operations, Inc. (Entergy) requested relaxation from Section IV.C(1)(b) of NRC Order EA-03-009 for Waterford Steam Electric Station, Unit 3 (Waterford 3) via Waterford 3 Relaxation Request #1. Specifically, the bottom ends of the Waterford 3 control element drive mechanism (CEDM) nozzles contain threads that cannot be effectively examined in accordance with the Order. Entergy provided supplemental information pertaining to this request via References 2 – 5. In Reference 6, the NRC staff granted Relaxation Request #1 for one operating cycle, which ends with upcoming refueling outage RF13.

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The conditions that required Entergy to submit relaxation to the Order remain under the requirements of the revised Order (i.e., CEDM nozzle configuration). Therefore, pursuant to Section IV.F of NRC Order EA-03-009 (revised), Entergy requests relaxation from Section IV.C.(5)(b) of the Order for Waterford 3. As with Relaxation Request #1, this request (Waterford 3 Relaxation Request #4) proposes an alternative based on stress and fracture mechanics analyses. Waterford 3 Relaxation Request #4 is provided in Enclosure 1.

Relaxation Request #4 is supported by:

1. Engineering Report M-EP-2003-004, Rev. 0, *Fracture Mechanics Analysis for the Assessment of the Potential for Primary Water Stress Corrosion Crack (PWSCC) Growth in the Uninspected Regions of the Control Element Drive Mechanism (CEDM) Nozzles at Waterford Steam Electric Station, Unit 3*, and

2. Dominion Engineering, Inc. Letter L-4162-00-1, *Material Properties and Modeling Methods Used in Waterford Unit 3 Welding Residual Stress Analyses.*

Entergy previously submitted these documents to the NRC staff via Reference 1.

This letter contains commitments as identified in Enclosure 2.

If you have any questions or require additional information, please contact Guy Davant at (601) 368-5756.

Sincerely,

FGB/GHD/ghd

Enclosures: 1. Waterford 3 Relaxation Request #4
2. Licensee-Identified Commitments

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ENCLOSURE 1

CNRO-2004-00020

WATERFORD STEAM ELECTRIC STATION, UNIT 3
RELAXATION REQUEST #4

ENTERGY OPERATIONS, INC.
WATERFORD STEAM ELECTRIC STATION, UNIT 3

RELAXATION REQUEST #4 TO NRC ORDER EA-03-009

I. ASME COMPONENTS AFFECTED

Waterford Steam Electric Station, Unit 3 (Waterford 3) has one hundred-two (102) ASME Class 1 reactor pressure vessel (RPV) head penetration nozzles comprised of ninety-one (91) Control Element Drive Mechanism (CEDM) nozzles, ten (10) Incore Instrument (ICI) nozzles, and one (1) vent line nozzle. See Figure 1 for penetration locations. This request pertains to the CEDM nozzles only.

In accordance with Section IV.A of NRC Order EA-03-009, the Waterford 3 susceptibility category is "high" based on a calculated value of greater than 12 effective degradation years (EDY) at the beginning of the upcoming spring refueling outage, RF13.

II. NRC ORDER EA 03-009 APPLICABLE EXAMINATION REQUIREMENTS

The NRC issued Revised Order EA-03-009 (the Order) that modified the current licenses at nuclear facilities utilizing pressurized water reactors (PWRs), which includes Waterford 3. The Order establishes inspection requirements for RPV head penetration nozzles. Waterford 3 is categorized as a "high" susceptibility plant based on an EDY value greater than 12.

Section IV.C of the Order states in part:

> All Licensees shall perform inspections of the RPV head using the following frequencies and techniques:
>
> (1) For those plants in the High category, RPV head and head penetration nozzle inspections shall be performed using the techniques of paragraph IV.C.(5)(a) and paragraph IV.C.(5)(b) every refueling outage.

Section IV.C.(5) of the Order states in part:

> (5) Inspections of the RPV head shall be performed as directed in paragraphs IV.C.(1), IV.C.(2), IV.C.(3), and IV.C.(4) using the following techniques:
>
> (a) Bare metal visual examination of 100% of the RPV head surface (including 360° around each RPV head penetration nozzle).
>
> (b) For each penetration, perform a nonvisual NDE in accordance with either (i), (ii), or (iii):
>
> (i) Ultrasonic testing of the RPV head penetration nozzle (i.e., nozzle base material) from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches); OR from 2 inches above the highest point

of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0 inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operating stresses) of 20 ksi tension and greater. In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel.

(ii) Eddy current testing or dye penetrant testing of the entire wetted surface of the J-groove weld and the wetted surface of the RPV head penetration nozzle base material from least 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches); OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0 inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operating stresses) of 20 ksi tension and greater.

(iii) A combination of (i) and (ii) to cover equivalent volumes, surfaces, and leak paths of the RPV head penetration nozzle base material and J-groove weld as described in (i) and (ii). Substitution of a portion of a volumetric exam on a nozzle with a surface examination may be performed with the following requirements:

1. On nozzle material below the J-groove weld, both the outside diameter and inside diameter surfaces of the nozzle must be examined.

2. On nozzle material above the J-groove weld, surface examination of the inside diameter surface of the nozzle is permitted provided a surface examination of the J-groove weld is also performed.

III. REASON FOR REQUEST

Section IV.F of the Order states in part:

Licensees proposing to deviate from the requirements of this Order shall seek relaxation of this Order pursuant to the procedure specified below. Project Directors or higher management positions in the Division of Licensing Project Management of the Office of Nuclear Reactor Regulation, may, in writing, relax or rescind any of the above conditions upon demonstration by the Licensee of good cause. A request for relaxation regarding inspection of specific nozzles shall also address the following criteria:

(1) The proposed alternative(s) for inspection of specific nozzles will provide an acceptable level of quality and safety, or

(2) Compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Requests for relaxation associated with specific penetration nozzles will be evaluated by the NRC staff using its procedure for evaluating proposed alternatives to the ASME Code in accordance with 10 CFR 50.55a(a)(3).

Pursuant to Section IV.F.(2) of the Order, Entergy Operations, Inc. (Entergy) requests relaxation from the requirements of Section IV.C.(5)(b). Entergy plans to inspect the RPV head CEDM penetration nozzles at Waterford 3 using the ultrasonic testing (UT) method in accordance with Section IV.C.(5)(b)(i) of the Order to the maximum extent possible. However, a UT inspection of the inside diameter (ID) of the CEDM nozzles at Waterford 3 can only be performed from 2 inches above the J-groove weld down to a point approximately 1.544 inches above the bottom of the nozzle. This 1.544-inch "blind zone" is due to limitations resulting from CEDM nozzle configuration (1.344 inches) and inspection probe design (0.200 inch). These limitations and their associated hardships are discussed in Sections III.A and III.B.

Entergy also evaluated the impact of inspecting the blind zone of each CEDM nozzle using either the liquid penetrant testing (PT) method or the eddy current testing (ECT) method as specified in Section IV.C.(5)(b)(ii) of the Order. Entergy found impracticality and hardship with these techniques, as discussed in Section III.C.

A. Nozzle Configuration Limitation

1. Description

Guide cones are attached to the bottoms of the Waterford 3 CEDM nozzles via threaded connections. Specifically, the guide cone screws into the end of the CEDM nozzle with a welded set screw and two tack welds at the cone-nozzle interface to secure the guide cone to the nozzle. The length of the threaded connection region is 1.25 inches. Additionally, a 45° chamfer exists immediately above the threaded connection region. The length of the chamfer region is 0.094 inch. (See Figure 2 for typical nozzle details.)

Due to the threaded connection and chamfer region at the bottom of each CEDM nozzle, a meaningful UT examination in that area cannot be performed. Specifically, the chamfer region geometry causes sporadic signals; and once the guide cone is reached, sound cannot pass into the CEDM nozzle base material because of the gap that exists between the guide cone and the nozzle at the threaded connection. Therefore, UT of the bottom 1.344 inches (1.25 + 0.094) of the CEDM nozzles is not possible.

2. Hardship

Resolving the UT limitations due to nozzle configuration would require eliminating the existing CEDM nozzle-to-guide cone threaded connection and chamfer region and redesigning and physically modifying the nozzle ends to provide for an acceptable UT examination. Entergy believes to take such an approach would impose hardships and unusual difficulties without a compensating increase in the level of quality and safety for the following reasons:

a) High Personnel Dose

As mentioned above, a guide cone is attached to the bottom of each CEDM nozzle via a threaded connection. Entergy has estimated that removing and reinstalling the 91 guide cones would result in personnel exposure of approximately 1.25 man-REM per nozzle for a total exposure of 113.75 man-REM.

b) Removing, Redesigning, and Reinstalling Guide Cones

The guide cones would be removed by cutting them off at the top of the nozzle threaded region, which would result in a shorter nozzle below the weld. As a result, the blind zone would be relocated closer to the weld reducing the length of nozzle below the weld that could be inspected via UT in future inspections.

The replacement guide cone is of a welded socket design that fits over the end of the nozzle and is welded to the nozzle tube. To reinstall the cones would require a modification to the nozzle ends as well as fabrication of new cones. Having to remove the cones and replace them with new components results in additional modifications to the RPV head. In addition, installing the new guide cone would cause high residual stresses in the heat affected zone of the weld, which would increase the probability of primary water stress corrosion cracking (PWSCC).

c) Impact on Outage Schedule

Entergy estimates that to remove and reinstall each guide cone would require approximately eight (8) hours per nozzle adding as much as 30 days to the outage schedule.

B. Inspection Probe Design Limitation

1. Description

The inspection probe to be used to inspect Waterford 3 CEDM nozzles consists of seven (7) individual transducers as shown in Figure 3. Various probe configurations will be utilized to perform the UT inspections [e.g., UT time-of-flight diffraction (TOFD) and standard 0° scans.]

The inspection probe is designed so that the ultrasonic transducers are slightly recessed into the probe holder. This recess must be filled with water to provide coupling between the transducer and the nozzle wall. Because of this design, the complete diameter of the transducer must fully contact the inspection surface before ultrasonic information can be collected. Because UT probes 1 and 2 have a diameter of 0.250 inch, these transducers should, in theory, be able to collect meaningful UT data down to a point approximately 0.125 inch (1/2 diameter) above the chamfer. However, based on prior UT inspection experience and a review of UT data from previous inspections, the circumferential-shooting TOFD transducer pair only collects meaningful data down to a point 0.200 inch above the chamfer. Below this point, UT data cannot be collected.

2. Hardship

Although Entergy continues to monitor and pursue improvements in non-destructive examination (NDE) capabilities, we know of no qualified UT equipment currently available that resolves the blind zone limitation. Therefore, new UT equipment would have to be developed and appropriately qualified. The time and resources required to develop this equipment is unknown.

C. Impracticality and Hardship of Performing Alternative Surface Examinations

To perform a PT inspection, the guide cones would have to be removed from and reinstalled on the CEDM nozzles before and after performing the PT examinations. Performing these operations would result in a significant increase in personnel radiation exposure. Entergy estimates that the radiation exposure associated with removing the guide cone, performing the PT inspection, and reinstalling the guide cone to be approximately 2.5 man-REM per nozzle for a total exposure of 227.5 man-REM. In addition, this option would also involve those hardships described in Sections III.A.2.a) and b), above.

As with the UT inspection, the bottom 1.344 inches (threaded connection and chamfer region) cannot be inspected using ECT.

In conclusion, CEDM nozzles can be volumetrically inspected in accordance with Section IV.C.(5)(b)(i) of the Order from 2 inches above the J-groove weld to the top of the blind zone (approximately 1.544 inches above the bottom of the nozzle). Below this point, Entergy believes that the hardships associated with inspection activities required by the Order as discussed above are not commensurate with the level of increased safety or reduction in probability of leakage that would be obtained by complying with the Order.

The NRC staff approved an equivalent relaxation request for Waterford 3 for the previous refueling outage RF12.[1]

[1] See NRC letter to Entergy Operations, Inc. (TAC No. MB9542), dated November 12, 2003.

IV. PROPOSED ALTERNATIVE AND BASIS FOR USE

Paragraph IV.C.(5)(b)(i) of the Order requires that the UT inspection of each RPV head penetration nozzle encompass from 2 inches above the highest point of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches); OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0 inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operating stresses) of 20 ksi tension and greater. In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel.

Due to the reasons stated above, Entergy requests relaxation from this requirement for Waterford 3 CEDM nozzles and proposes an alternative, which involves the use of UT examination, analysis, and augmented inspection techniques, as described below.

A. Proposed Alternative

1. UT Examination

The ID of each CEDM nozzle (i.e., nozzle base material) shall be ultrasonically examined from two (2) inches above the J-groove weld to 1.544 inches above the bottom of the nozzle. In addition, an assessment to determine if leakage has occurred into the interference fit zone will be performed, as currently specified in Section IV.C.(5)(b)(i) of the Order.

2. Analysis

For the blind zone portions of the CEDM nozzle not examined by UT as required by the Order, analysis has been performed to determine if sufficient free-span exists between the blind zone and the weld to facilitate one (1) operating cycle of crack growth without the crack reaching the weld.

The analysis is summarized in Section IV.B.2 below and is fully documented in Engineering Report M-EP-2003-004, Rev. 0.[2]

As discussed in Section IV.B.2, the analysis was based on a detailed review of applicable Waterford 3 design drawings and actual UT data from a sister plant. During previous refueling outage RF12 at Waterford 3, Entergy inspected by UT each CEDM nozzle to determine its actual as-built configuration. These inspections confirmed that the as-built nozzle configurations were bounded by the analysis.

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[2] Engineering Report M-EP-2003-004, Rev. 0 was transmitted to the NRC via Entergy letter CNRO-2003-00038 dated September 15, 2003.

B. Basis for Use

The UT examination is the volumetric technique recognized in Section IV.C.(5)(b)(i) of the Order. The Entergy proposed alternative includes the use of UT to the maximum extent practical based on the limits of current technology. However, because the technology cannot provide an inspection to the extent required by the Order, Entergy proposes to use supplemental analysis. This approach provides a level of safety and quality commensurate with the intent of the Order. Each portion of the proposed alternative is discussed below.

1. UT Examination

UT inspection of CEDM nozzles will be performed using a combination of TOFD and standard 0° pulse-echo techniques. The TOFD approach utilizes two pairs of 0.250-inch diameter, 55° refracted-longitudinal wave transducers aimed at each other. One of the transducers sends sound into the inspection volume while the other receives the reflected and diffracted signals as they interact with the material. There will be one TOFD pair looking in the axial direction of the penetration nozzle tube and one TOFD pair looking in the circumferential direction of the tube. The TOFD technique is primarily used to detect and characterize planar-type defects within the full volume of the tube.

The standard 0° pulse-echo ultrasonic approach utilizes one 0.250-inch diameter straight beam transducer. The 0° technique is used to:

- Plot the penetration nozzle outside diameter (OD) location and weld location,
- Locate and size any laminar-type defects that may be encountered, and
- Monitor the back-wall signal response to detect leakage that may occur in the interference regions of the RPV head penetration.

The UT inspection procedures and techniques to be utilized at Waterford 3 have been satisfactorily demonstrated under the EPRI Materials Reliability Program (MRP) Inspection Demonstration Program.

2. Analysis

The extent of the proposed alternative is established by an engineering evaluation that includes a finite element stress analysis and fracture mechanics evaluations. The intent of the engineering evaluation is to determine whether sufficient crack propagation length exists between the tip of a postulated crack and the weld to facilitate one cycle of crack growth without the crack reaching the weld. See Figure 4.

Four (4) CEDM nozzle locations were selected for analysis in the engineering evaluation. The selected locations (RPV head angles) were 0°, 7.8°, 29.1°, and 49.7° with the 0° head angle at the vertical centerline of the RPV head, the 49.7° head angle location being the outermost nozzles, and the other two being intermediate locations between the center and outermost locations. The results of the stress analysis at each location are bounding for nozzles higher on the head (e.g., analysis for 29.1° bounds the intermediate nozzles between 7.8° and 29.1°). The selected nozzle head angle locations provide an adequate representation of residual stress profiles and a proper basis for analysis to bound all CEDM nozzles. Based on these analyses, each nozzle was evaluated to determine whether the available propagation length as defined by UT data was adequate to prevent crack propagation into the weld in less than one cycle of operation. The stress analyses and fracture mechanics evaluations performed to address these conditions are summarized below.

Stress Analysis

A "finite element" based stress analysis was performed on the Waterford 3 CEDM nozzles in this evaluation. For conservatism, the yield strength used in the analysis for each nozzle head angle location is the highest yield strength of all the nozzles at that head angle. Inspections of the RPV head penetrations had not been performed at Waterford 3 prior to RF12, the nozzle dimensions were determined by a detailed review of applicable Waterford 3 design drawings and actual UT data from a sister plant. Like Waterford 3, the sister plant is of similar CE design rated at 3410 MWt.

Estimated as-built free-span lengths for each nozzle group are provided in Figure 3 of Engineering Report M-EP-2003-004 and presented in the table below.

Nozzle Group	Azimuthal Location	Estimated Free-Span (inches)
0°	All	1.03
7.8°	Downhill	1.01
	Uphill	1.66
29.1°	Downhill	0.64
	Uphill	3.50
49.7°	Downhill	0.42
	Uphill	6.18

As stated in Section IV.A.2, Entergy confirmed by inspection during RF12 that the as-built nozzle configurations were bounded by the analyses.

Based on this review, the following points were concluded:

- <u>CEDM Nozzles at 0° and 7.8° Head Angle Locations</u>: The dimension from the top of the blind zone to the top of the weld is longer than that indicated by design. As a result, the root of the weld is higher. The leg lengths of the welds on the downhill and uphill sides of the nozzles match design. This information indicates a larger weld throat dimension, and as a result, a larger radial dimension at the ID surface of the RPV head. The FEA model has been adjusted for this larger weld size.

- <u>CEDM Nozzles at 29.1° and 49.7° Head Angle Locations</u>: The dimension from the top of the blind zone to the top of the weld is longer than that indicated by design. As a result, the root of the weld is higher. This information indicated a larger weld throat dimension, and as a result, a larger radial dimension at the ID surface of the RPV head. In addition, the leg lengths of the welds on the downhill sides of the nozzles are longer than indicated by design. The FEA model has been adjusted to account for the larger weld size.

- <u>CEDM Nozzles at 42.4° Head Angle Locations</u>: Although a stress analysis and fracture mechanics analysis is not performed on nozzles at the 42.4° head angle location, the as-built configuration of these nozzles was also evaluated to provide additional assurance that the FEA adequately models the as-built condition of all nozzles bounded by the 49.7° head angle location. Based on this review, all observations noted above for the weld at the 49.7° nozzle were also observed at the 42.4° head angle location. Therefore, this review provided additional assurance about the accuracy of the FEA model.

The FEA for the analyzed nozzles determined the stress distribution from the bottom of the nozzle to just above the top of the weld at the downhill, uphill, and mid-plane azimuthal locations. The downhill and mid-plane locations were selected for analysis because they represent the shortest distances that a crack has to propagate to reach the nozzle weld region. The uphill location was selected for completeness of the analysis. The results of the FEA are presented in Figures 4 through 17 and Tables 1 through 10 of Engineering Report M-EP-2003-004, Rev. 0. The stress distributions produced by this analysis were used to perform the fracture mechanics evaluations.

<u>Fracture Mechanics Evaluation</u>

Safety analyses performed by the MRP have demonstrated that axial cracks in the nozzle tube material do not pose a challenge to the structural integrity of the nozzle. However, axial cracks may lead to pressure boundary leaks above the weld that could produce OD circumferential cracks and structural integrity concerns. Therefore, proper analysis of potential axial cracks in the blind zone of the CEDM nozzle is essential.

The analyses performed in the engineering evaluation were designed to determine the behavior of postulated cracks that could exist in the blind zone. Hence, the crack growth region is from the top of the blind zone to the bottom of the weld. The design review of the RPV head construction, the detailed residual stress analysis, selection of representative nozzle locations, utilization of representative fracture mechanics models, and the application of a suitable crack growth law provide a sound basis for the engineering evaluation.

Postulated cracks for the analysis include axial ID and OD part through-wall and through-wall cracks. Axial cracks are selected for evaluation in this analysis because of their potential to propagate to the weld region. Axial ID and OD part through-wall crack sizes equal twice the smallest crack sizes successfully detected by UT under the EPRI MRP Inspection Demonstration Program. Part through-wall cracks were centered at the top of the blind zone in the analysis. Through-wall cracks were postulated to exist from the top of the blind zone down to a point where the hoop stress is ≤ 10 ksi, which is more conservative than the value of 20 ksi allowed in the revised Order. The ID and OD part through-wall and through-wall cracks were located along the circumference of each nozzle at the 0° (downhill), 90° (mid-plane), and 180° (uphill) azimuthal locations, 0° (downhill) the furthest point from the center of the RPV head.

Thirty (30) different cases have been analyzed using crack growth rates from EPRI Report MRP-55, *Material Reliability Program – Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick-Wall Alloy 600 Material.* In summary, the evaluation results from all cases demonstrated that postulated flaws in the blind zone region will not compromise the weld in one cycle of operation. The analysis further demonstrated that a larger margin exists (i.e. longer than one fuel cycle) at all evaluated locations. Because stresses at the postulated crack locations produce a stress intensity factor that is less than the threshold value, OD part through-wall and through wall cracks are not even susceptible to crack growth by PWSCC. With respect to ID part through-wall cracks, none of these cracks came close to reaching the bottom of the weld or penetrating through the nozzle wall to the weld interface in one cycle of operation. Results of the fracture mechanics evaluations are documented in Table 13 of Engineering Report M-EP-2003-004, Rev. 0.

Additional Analyses

The fracture mechanics evaluations described above assessed the potential for postulated cracks to propagate from the top of the blind zone to the weld in less than one cycle of plant operation. The potential for postulated cracks to propagate from the bottom of the blind zone to the weld was also evaluated. In general, the stress analysis indicated that the magnitude of the hoop stress distribution from the top of the blind zone to the bottom of the nozzle along both the ID and OD surfaces decreases steadily and becomes compressive. The extent, or height, of the compression zone for each nozzle group and azimuthal location is presented in Table 12 of Engineering Report M-EP-2003-004 and is summarized below.

Nozzle Group	Azimuthal Location	Compression Zone Height	Maximum Hoop Stress Where No Compression Zone Exists
0°	All	0.89 inch	N/A
7.8°	Downhill	0.97 inch	N/A
	Uphill	1.26 inch	N/A
	Mid-plane	1.059 inch	N/A
29.1°	Downhill	1.148 inch	N/A
	Uphill	0 inch	< 10 ksi
	Mid-plane	0 inch	< 10 ksi
49.7°	Downhill	0 inch	< 10 ksi
	Uphill	0 inch	< 10 ksi
	Mid-plane	0 inch	19.02 ksi

The height of the compression zone is measured from the bottom of the nozzle. Within the compression zone regions, no PWSCC-assisted crack growth is possible. For those nozzle groups with a tensile stress below 10 ksi, the possibility for PWSCC crack initiation is extremely low.

However, the FEA also indicated that a hoop stress of 19.02 ksi exists along the bottom of the 49.7° CEDM nozzle at the mid-plane location. Because of this higher stress value, this nozzle location was selected for additional analysis by fracture mechanics. Based on this analysis, postulated cracks at the bottom of the 49.7° nozzle (mid-plane) do not propagate into the weld in less than one cycle of plant operation. Furthermore, the analysis results indicate that the postulated cracks in the region do not reach the weld in nearly forty (40) years of operation. For additional details, see the Additional Analysis subsection of Section 5.0 in Engineering Report M-EP-2003-004, Rev. 0.

Analysis Conclusions

Fracture mechanics evaluations were performed at the downhill, uphill, and mid-plane locations of the 0°, 7.8°, 29.1°, and 49.7° CEDM nozzles to assess the potential for postulated cracks to grow from the blind zone to the nozzle weld in less than one cycle of plant operation. Additional analyses were performed to assess the potential for postulated cracks to grow from along the bottom of the 49.7° CEDM nozzle at the mid-plane location to the weld in one cycle of operation. The evaluations indicate that cracks in the blind zone of the CEDM nozzle will not grow into the welds of any of the 91 CEDM nozzles at Waterford 3 within one cycle of operation. See Table 1 which identifies the nozzle locations bounded by these evaluations. For details regarding the engineering evaluation and its conclusions, see Engineering Report M-EP-2003-004, Rev. 0 (Enclosure 2).

This analysis incorporates a crack-growth formula different from that described in Footnote 1 of the Order, as provided in EPRI Report MRP-55. Entergy is aware that the NRC staff has not yet completed a final assessment regarding the acceptability of the EPRI report. If the NRC staff finds that the crack-growth formula in MRP-55 is unacceptable, Entergy shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs Entergy of an NRC-approved crack-growth formula. If Entergy's revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of Operating Cycle 14 (following the upcoming refueling outage), Entergy will, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack growth acceptance criteria are exceeded during the subsequent operating cycle, Entergy shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either Operating Cycle 14 or the subsequent operating cycle, Entergy shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for Operating Cycle 14 and future cycles for RPV head penetrations will be based on an NRC-acceptable crack growth rate formula.

Verification of Nozzle Configuration Input Perimeters

As addressed in Section IV.A.2, the stress analysis employed in the engineering evaluation utilized nozzle configuration information gleaned from design drawings and UT inspection data from a sister plant. Using UT inspection results from the fall 2003 refueling outage (RF12), Entergy evaluated the actual as-built nozzle configurations to that assumed in the analysis. By determining each nozzle's configuration, Entergy validated the results of the analysis.

V. CONCLUSION

Section IV.F of the Order states in part:

> Licensees proposing to deviate from the requirements of this Order shall seek relaxation of this Order pursuant to the procedure specified below. The Director, Office of Nuclear Reactor Regulation, may, in writing, relax or rescind any of the above conditions upon demonstration by the Licensee of good cause. A request for relaxation regarding inspection of specific nozzles shall also address the following criteria:
>
> (1) The proposed alternative(s) for inspection of specific nozzles will provide an acceptable level of quality and safety, or
>
> (2) Compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Section IV.C.(5)(b) of the Order establishes a minimum set of RPV head penetration nozzle inspection requirements to identify the presence of cracks in penetration nozzles that could lead to leakage of reactor coolant and wastage of RPV head material.

Entergy believes that compliance with the UT inspection provisions of Section IV.C.(5)(b)(i) of the Order for the CEDM nozzles as described in Section II above would result in hardships and unusual difficulties, as discussed in Section III above, without a compensating increase in the level of quality and safety.

Entergy believes the proposed alternative, described in Section IV, provides an acceptable level of quality and safety by utilizing inspections and supplemental analysis to determine the condition of the Waterford 3 CEDM nozzles. The technical basis for the supplemental analysis and the augmented inspections of the proposed alternative is documented in Engineering Report M-EP-2003-002, Rev. 1, which was previously submitted to the NRC staff. Therefore, Entergy requests that the proposed alternative be authorized pursuant to Section IV.F of the Order.

As mentioned in Section III, the NRC staff approved an equivalent relaxation request for Waterford 3 for the previous refueling outage RF12.[3]

[3] See NRC letter to Entergy Operations, Inc. (TAC No. MB9542), dated November 12, 2003.

TABLE 1

Summary of CEDM Nozzle Locations Bounded by Analysis

Analyzed CEDM Nozzle Location	CEDM Nozzle Locations Bounded By Analysis	
	Head Angle Location	Nozzle Number
0°	0°	1
7.8°	7.8°	2, 3
29.1°	11.0°	4, 5, 6, 7
	15.6°	8, 9, 10, 11
	17.5°	12,13, 14, 15, 16, 17, 18, 19
	22.4°	20, 21, 22, 23
	23.9°	24, 25, 26, 27
	25.2°	28, 29, 30, 31, 32, 33, 34, 35
	29.1°	36, 37, 38, 39, 40, 41, 42, 43
49.7°	32.7°	44, 45, 46, 47
	33.8°	48, 49, 50, 51, 52, 53, 54, 55
	34.9°	56, 57, 58, 59
	37.1°	60, 61, 62, 63, 64, 65, 66, 67
	42.4°	68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79
	43.4°	80, 81, 82, 83, 84, 85, 86, 87
	49.7°	88, 89, 90, 91

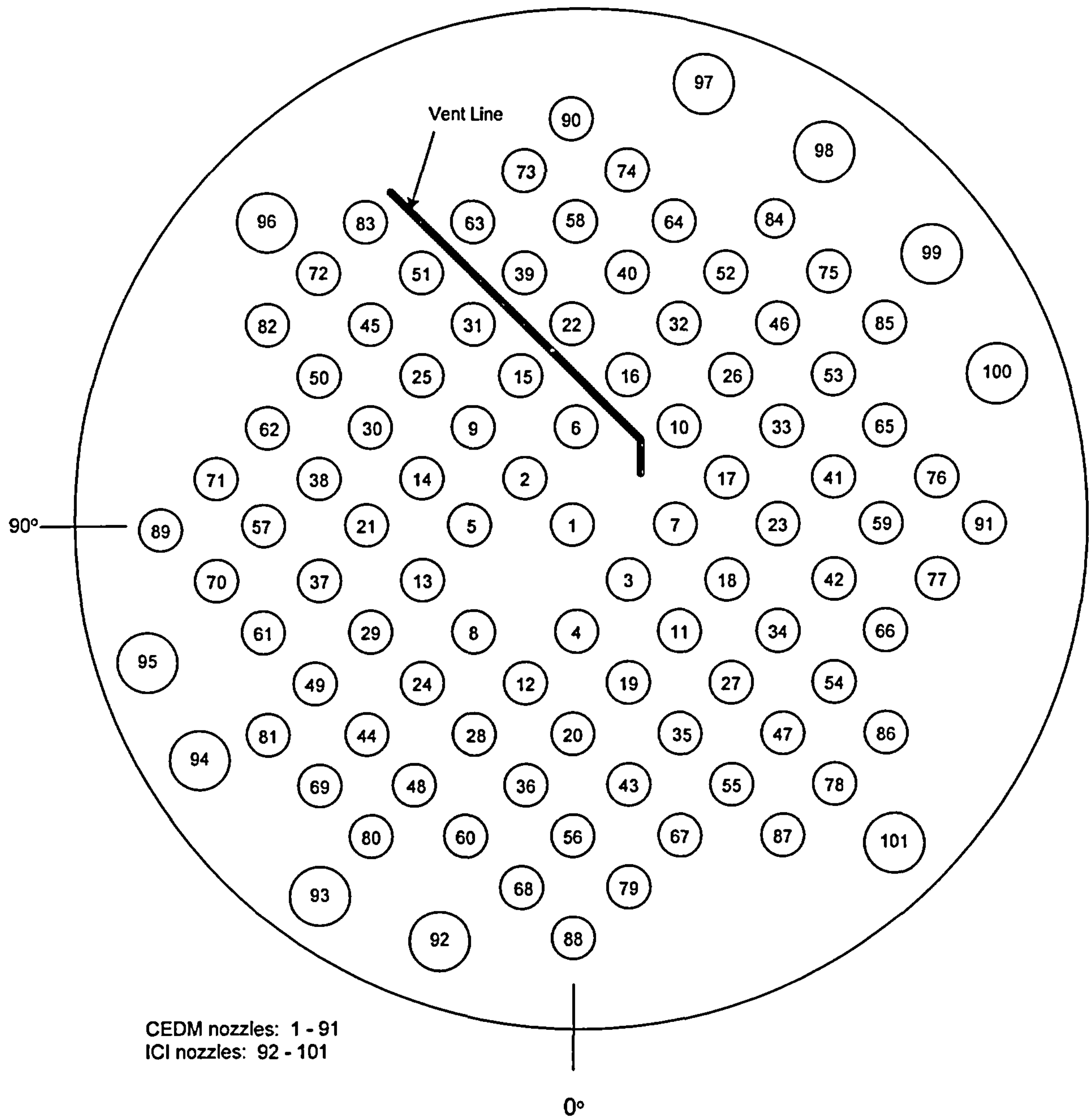


FIGURE 1
Penetration Locations in the Waterford 3 RPV Head

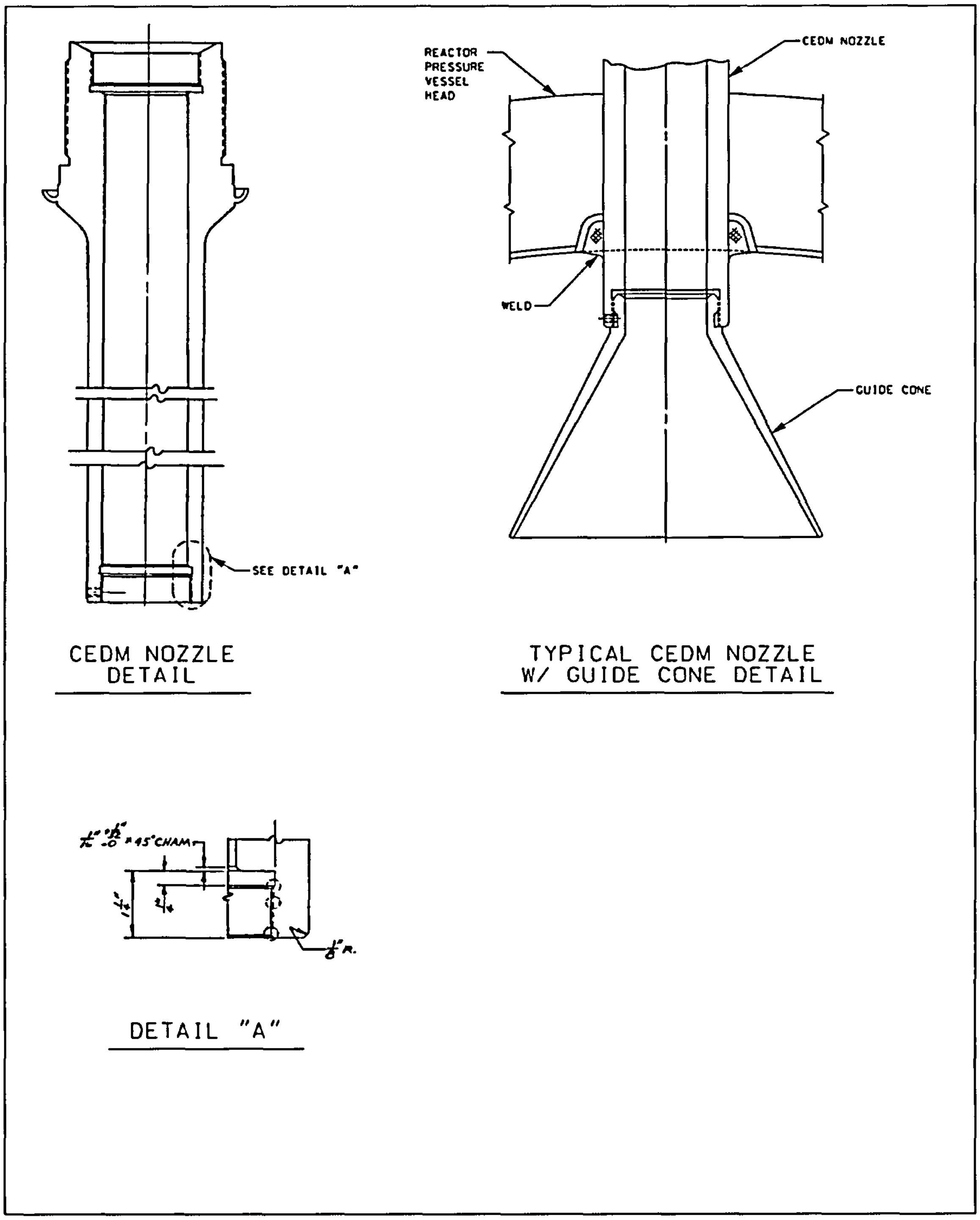
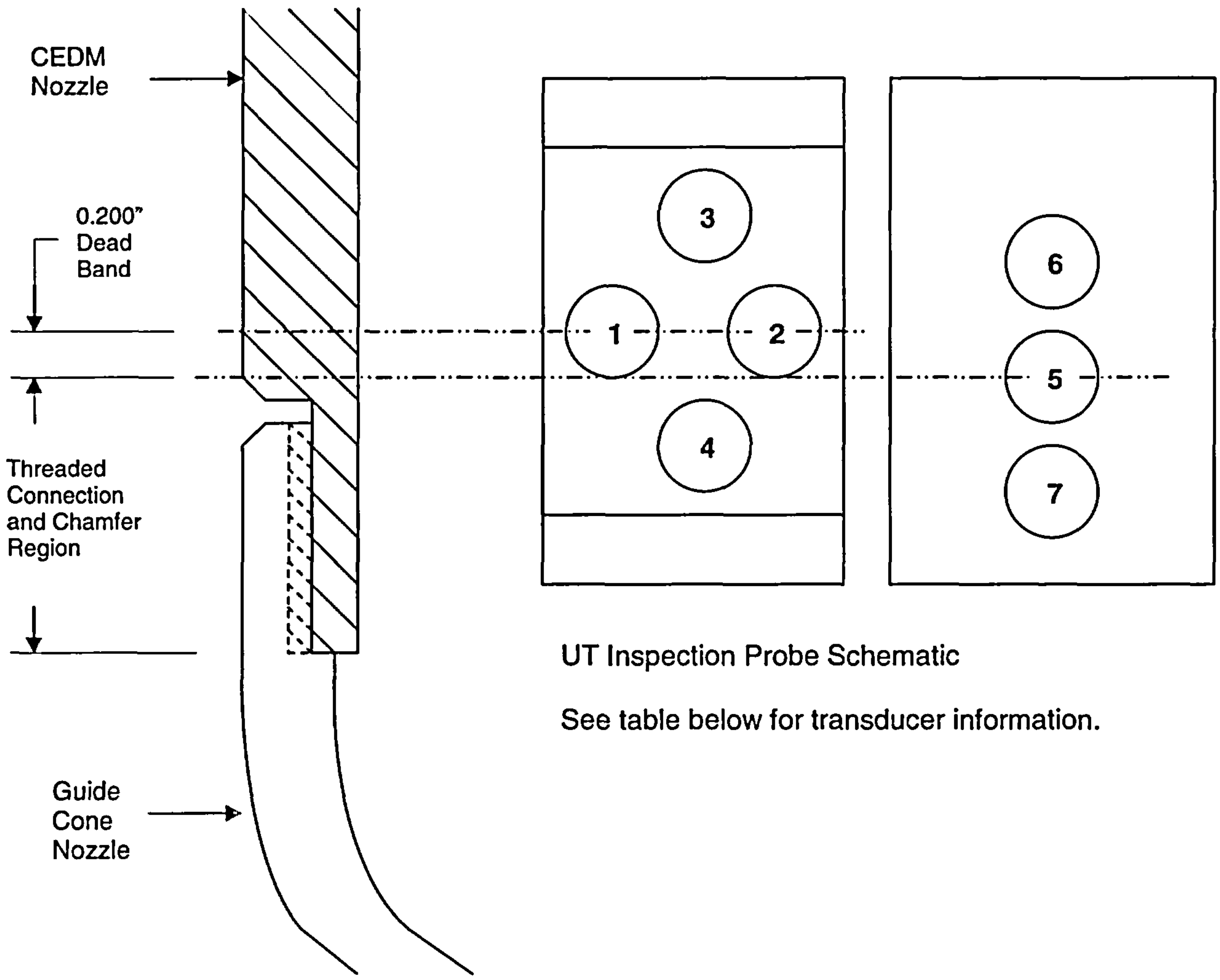


FIGURE 2
TYPICAL CEDM NOZZLE DETAILS



UT Inspection Probe Schematic

See table below for transducer information.

Position	Mode	Diameter	Description
1	Transmit	0.25 inch	Circumferential Scan Using TOFD
2	Receive	0.25 inch	Circumferential Scan Using TOFD
3	Transmit	0.25 inch	Axial Scan Using TOFD
4	Receive	0.25 inch	Axial Scan Using TOFD
5	Transmit Receive	0.25 inch	Standard Zero Degree Scan
6	Transmit Receive	0.25 inch	Standard Zero Degree Scan
7	N/A	0.25 inch	Eddy Current

FIGURE 3
TYPICAL UT INSPECTION PROBE DETAIL

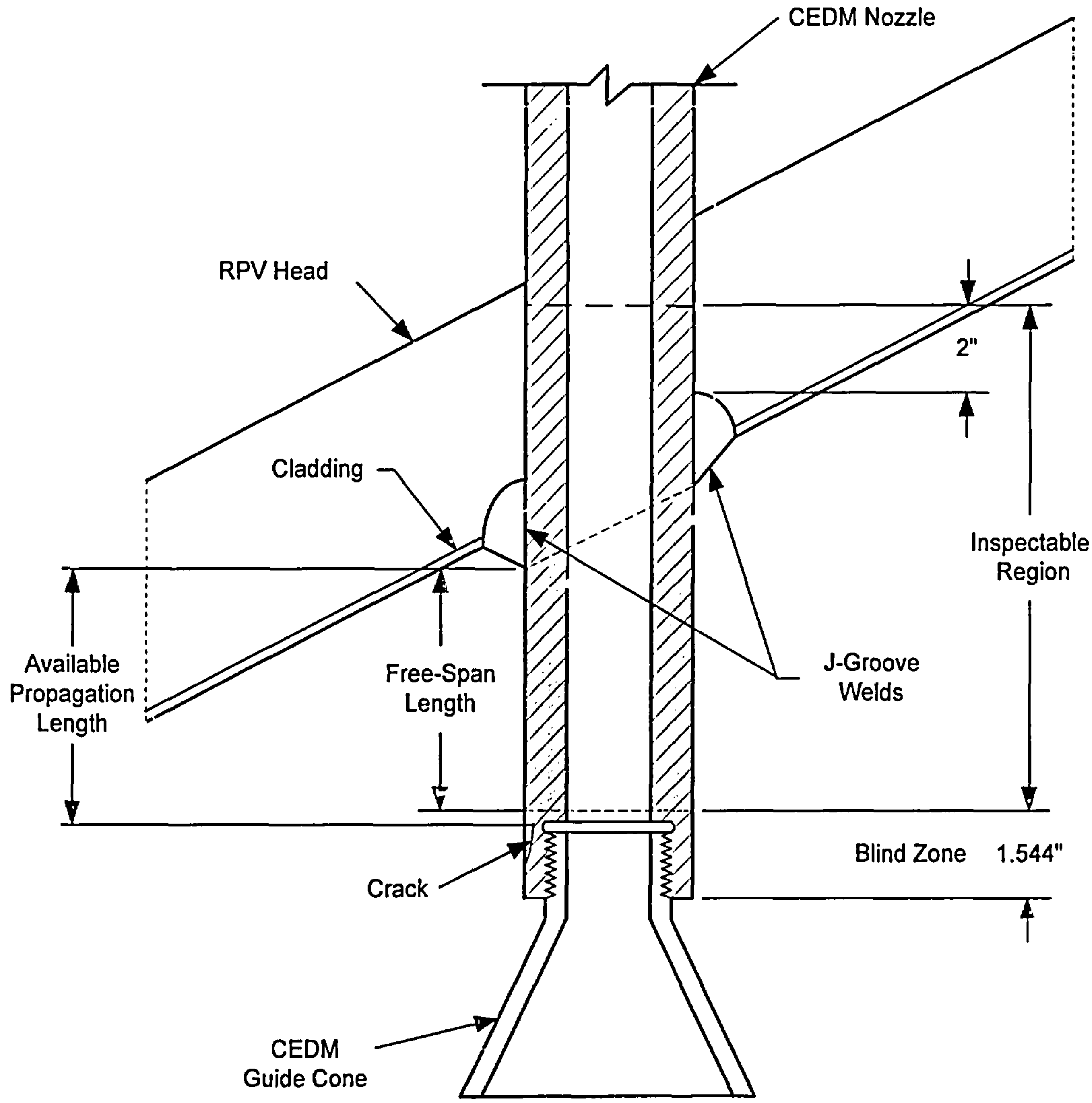


FIGURE 4
DETAIL OF CEDM NOZZLE CRACK GROWTH ANALYSIS

ENCLOSURE 2

CNRO-2004-00020

LICENSEE-IDENTIFIED COMMITMENTS

LICENSEE-IDENTIFIED COMMITMENTS

COMMITMENT	TYPE (Check one) ONE-TIME ACTION	TYPE (Check one) CONTINUING COMPLIANCE	SCHEDULED COMPLETION DATE
1. As required by Section IV.E of the Order, the final results of the inspections will be provided in the 60-day report submitted to the NRC.		✓	60 days after startup from the next refueling outage
2. If the NRC staff finds that the crack-growth formula in MRP-55 is unacceptable, Entergy shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs Entergy of an NRC-approved crack-growth formula.	✓		Within 30 days after the NRC informs Entergy of an NRC-approved crack-growth formula.
3. If Entergy's revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of Operating Cycle 14 (following the upcoming refueling outage), this relaxation is rescinded and Entergy will, within 72 hours, submit to the NRC written justification for continued operation.	✓		Within 72 hours from completing the revised analysis in #2, above.
4. If the revised analysis shows that the crack growth acceptance criteria are exceeded during the subsequent operating cycle, Entergy shall, within 30 days, submit the revised analysis for NRC review.	✓		Within 30 days from completing the revised analysis in #2, above.
5. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either Operating Cycle 14 or the subsequent operating cycle, Entergy shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised.	✓		Within 30 days from completing the revised analysis in #2, above.
6. Any future crack-growth analyses performed for Operating Cycle 14 and future cycles for RPV head penetrations will be based on an acceptable crack growth rate formula.		✓	N/A